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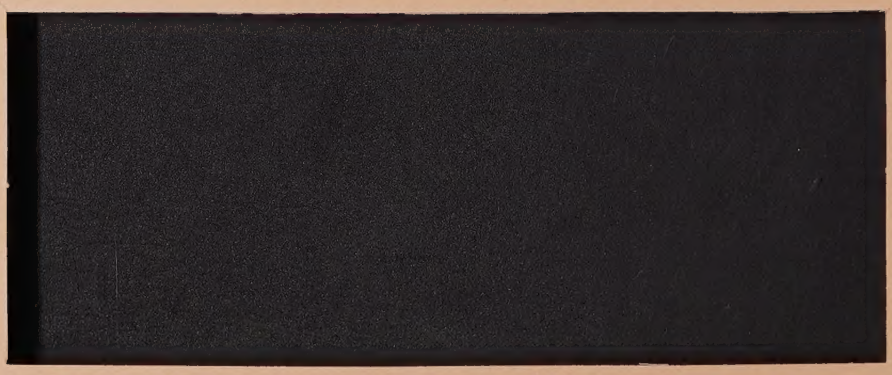
INSTRUCTION MANUAL



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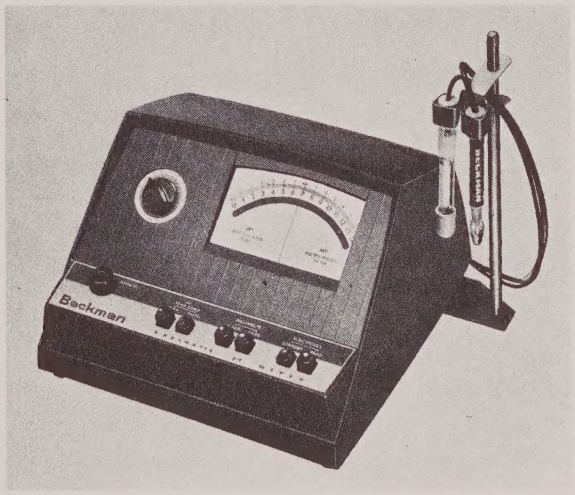
Beckman Operating and Maintenance Instructions



Zeromatic® pH Meter

Beckman Instruments, Inc.
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Beckman® INSTRUMENTS, INC.

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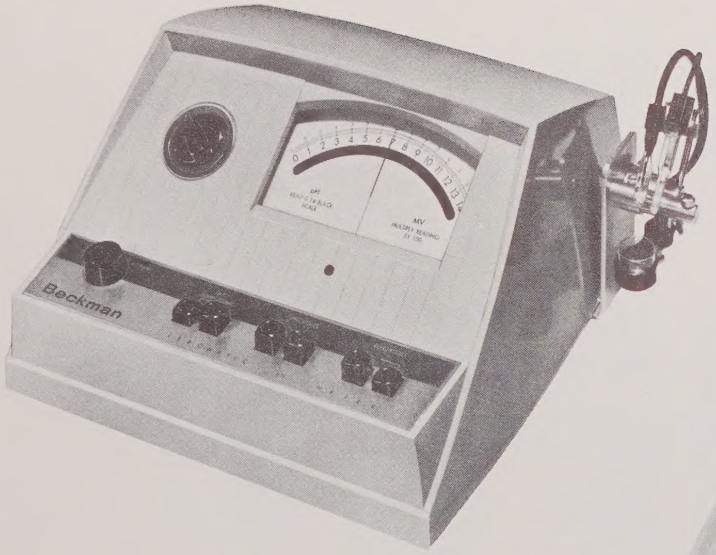
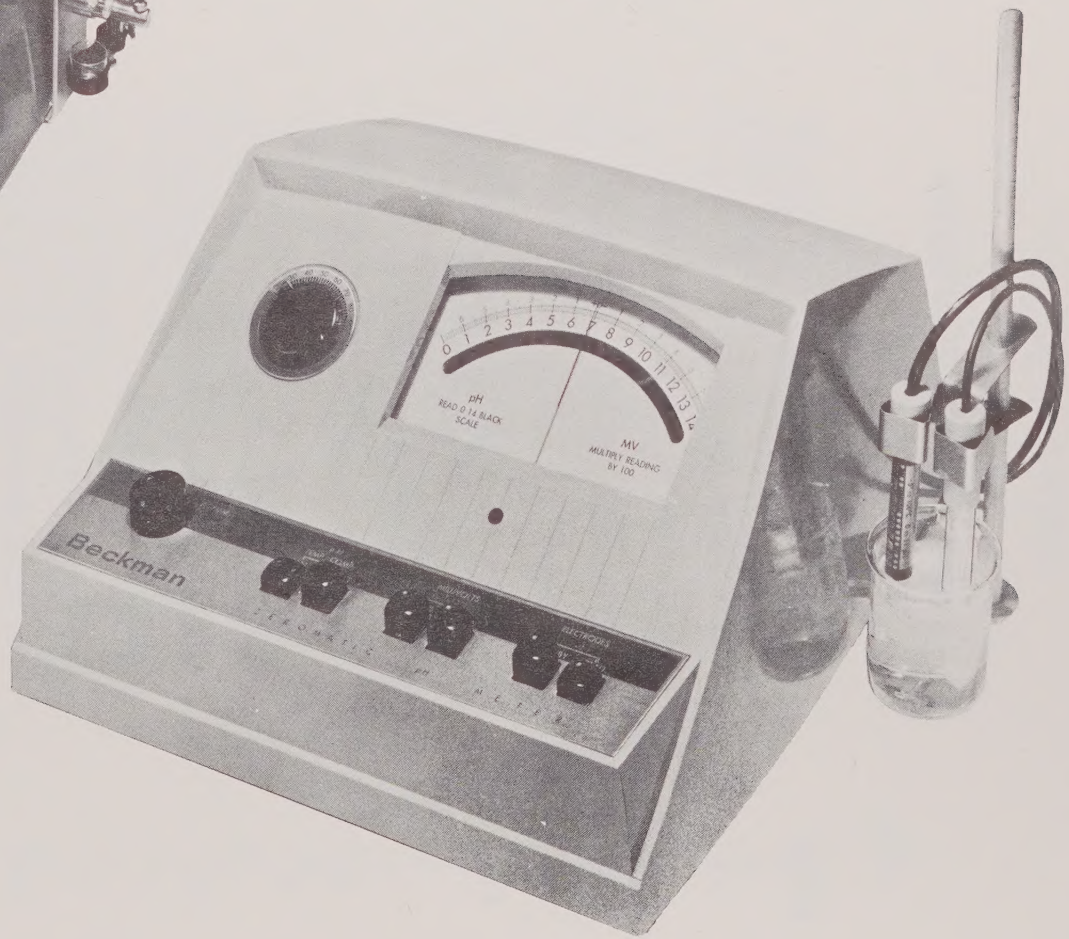


9602 ZEROMATIC
with Swing Arm Assembly



9600 ZEROMATIC
with Standard Electrodes
and Holder

FIGURE 1. ZEROMATIC pH METERS

SECTION 1

1. INTRODUCTION

1.1 GENERAL

The BECKMAN ZEROMATIC pH Meter is a versatile laboratory instrument which may be used either for making pH determinations in the 0 - 14 pH range, or for millivolt measurements. Millivolt measurements may be made in either of two ranges: ±700 millivolts, or within a 1400 millivolt span, with zero set at any desired point on the scale.

The ZEROMATIC features push-button controls, board and eyelet construction, and the ZEROMATIC Amplifier, which provides automatic zero standardization once each second. The instrument utilizes standard BECKMAN Glass and Reference Electrodes, as well as BECKMAN Metallic and Special-Purpose Electrodes.

Temperature corrections may be made manually with the Temperature Adjustment Control, or automatically by using the BECKMAN 39096 Thermo-Compensator. Connections are provided on the Terminal Board of the instrument for the Thermo-Compensator.

Determinations of pH values or of millivolt measurements may be read directly from the Meter on the front panel of the ZEROMATIC. The instrument may be used also with a potentiometer-type recorder, or with a current-type recorder.

The 9600 and 9601 ZEROMATIC pH Meters are supplied with a rigid Electrode Holder and standard-size Glass and Reference Electrodes. The 9602 and 9603 ZEROMATICS are supplied with a Swing-Arm Electrode Holder and special small-size Electrodes. In addition, the 9601-9603 (Export Models) are provided with a special Power Transformer which permits operation of the instrument on a-c voltages from 110 to 250 volts, at frequencies of 40 to 60 cycles.

1.2 SPECIFICATIONS.

(1) Input Power:

115 volts (±15%), 50-60 cycles, 15 watts (9600-9602 only).

(2) Warm-Up Time:

2 minutes.

(3) pH Range:

0 - 14 pH.

(4) Millivolt Range:

(a) 700-0-700 millivolts.

(b) 1400 millivolt span, with zero set at any desired point on scale.

(5) Accuracy:

0.1 pH.

(6) Reproducibility:

0.02 pH.

(7) Input:

(a) Standard BECKMAN Glass Electrodes.

(b) Standard BECKMAN Reference Electrodes.

(c) BECKMAN Metallic and some Special-Purpose Electrodes.

(d) BECKMAN 39096 Thermo-Compensator.

(8) Presentation:

(a) Visual - Meter, mirror-scale type, scale length 5.5 inches.

(b) Chart - Terminals provided for attaching either:

1. Recorder, potentiometer-type; sensitivity 200 millivolts, or less; zero center scale, (or use zero-shifting network).

Or

2. Recorder, current-type; sensitivity 200 microamperes (more sensitive recorders can be shunted to 200 microamperes); zero center scale (or use zero-shifting network); recorder resistance less than 1000 ohms.

1.3 OPERATING CONTROLS.

1.3.1 Push-Buttons.

The principal operational functions of the ZEROMATIC are controlled by six push-buttons on the front panel of the instrument. These push-buttons actually constitute two switches, providing a convenient means of selecting functions of the instrument, controlling the relationship of the Electrodes to the input of the instrument, and placing the ZEROMATIC Amplifier in operation for pH determinations or millivolt measurements.

The two Electrode push-buttons (marked STANDBY and READ) are interlocked; depressing either of these push-buttons automatically releases the other. These push-buttons control the relationship of the Electrodes to the input of the instrument, and also the operation of the relay in the ZEROMATIC circuit.

The four remaining push-buttons, grouped in pairs under pH TEMP. COMP. and MILLIVOLTS are interlocked, and provide a means of selecting the function of the instrument. The pH TEMP. COMP. push-buttons offer choice of manual temperature compensation (MAN.), or automatic temperature compensation (AUTO.).

The two MILLIVOLT push-buttons offer a choice between a 700-0-700 millivolt span (±700 push-button), and a 1400 millivolt span (1400 push-button). When the 1400 push-button is depressed, zero may be set at any desired point on the scale by adjusting the Asymmetry Control (ASYMM.).

1.3.2 Asymmetry Control.

The Asymmetry Control (ASYMM.) provides a means of adjusting the ZEROMATIC to compensate for variations in Electrode "zero-potentials." This control is also used to set the desired zero position on the Meter scale when the instrument is used for millivolt measurements in the 1400 mv range.

1.3.3 Temperature Adjustment Control.

The Temperature Adjustment Control (TEMP. °C) provides a means of making manual temperature compensation adjustments when the ZEROMATIC is used without the Thermo-Compensator. This control is inoperative when the AUTO. Push-Button is depressed; thus it is not in the circuit when pH measurements are made with the Thermo-Compensator connected or for millivolt measurements.

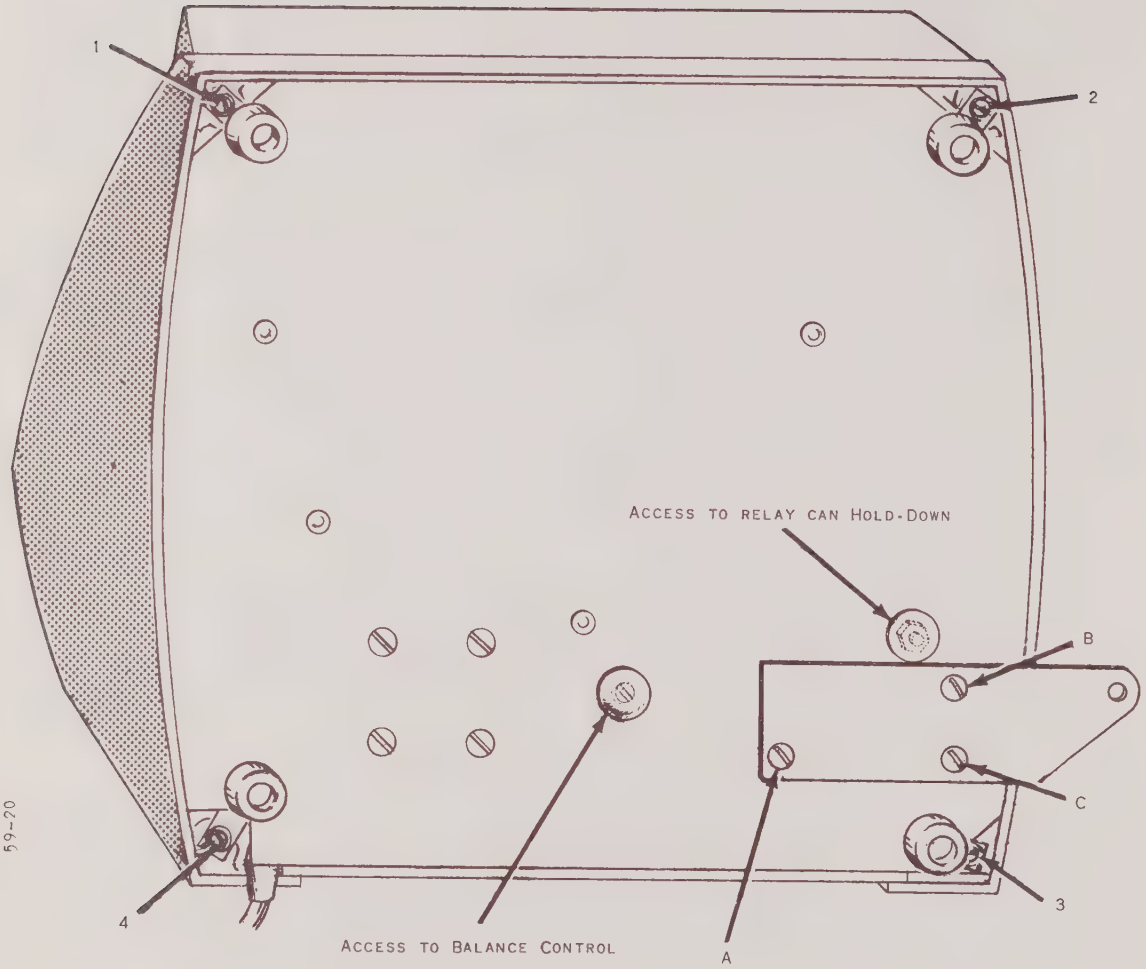


FIGURE 2. BOTTOM VIEW OF ZEROMATIC

SECTION 2

2. PRELIMINARY PROCEDURE

2.1 ELECTRODE PREPARATION.

The ZEROMATIC pH Meter is supplied with a standard BECKMAN Reference Electrode (Asbestos fiber type), and a BECKMAN Glass Electrode of the general purpose type; these are suitable for most applications. Other types of BECKMAN electrodes available through your BECKMAN Dealer, are described and illustrated in Bulletin 86.

To prepare the Electrodes for use with the ZEROMATIC, follow the procedures outlined below:

(1) Remove the rubber protector from the lower end of the Reference Electrode, and slide Sleeve down so side filling hole is open.

(2) If the saturated KCl solution in the Reference Electrode has become depleted, refill with BECKMAN KCl solution.

> NOTE
>
> The Reference Electrode should always be kept nearly full of KCl solution.

(3) Soak the Glass Electrode in distilled water for several hours before use.

> NOTE
>
> Complete instructions are supplied with each Electrode.

2.2 ELECTRODE INSTALLATION

The 9600 and 9601 ZEROMATIC pH Meters are provided with a rigid Electrode Holder, consisting of a Support Rod and a Bracket for attaching to

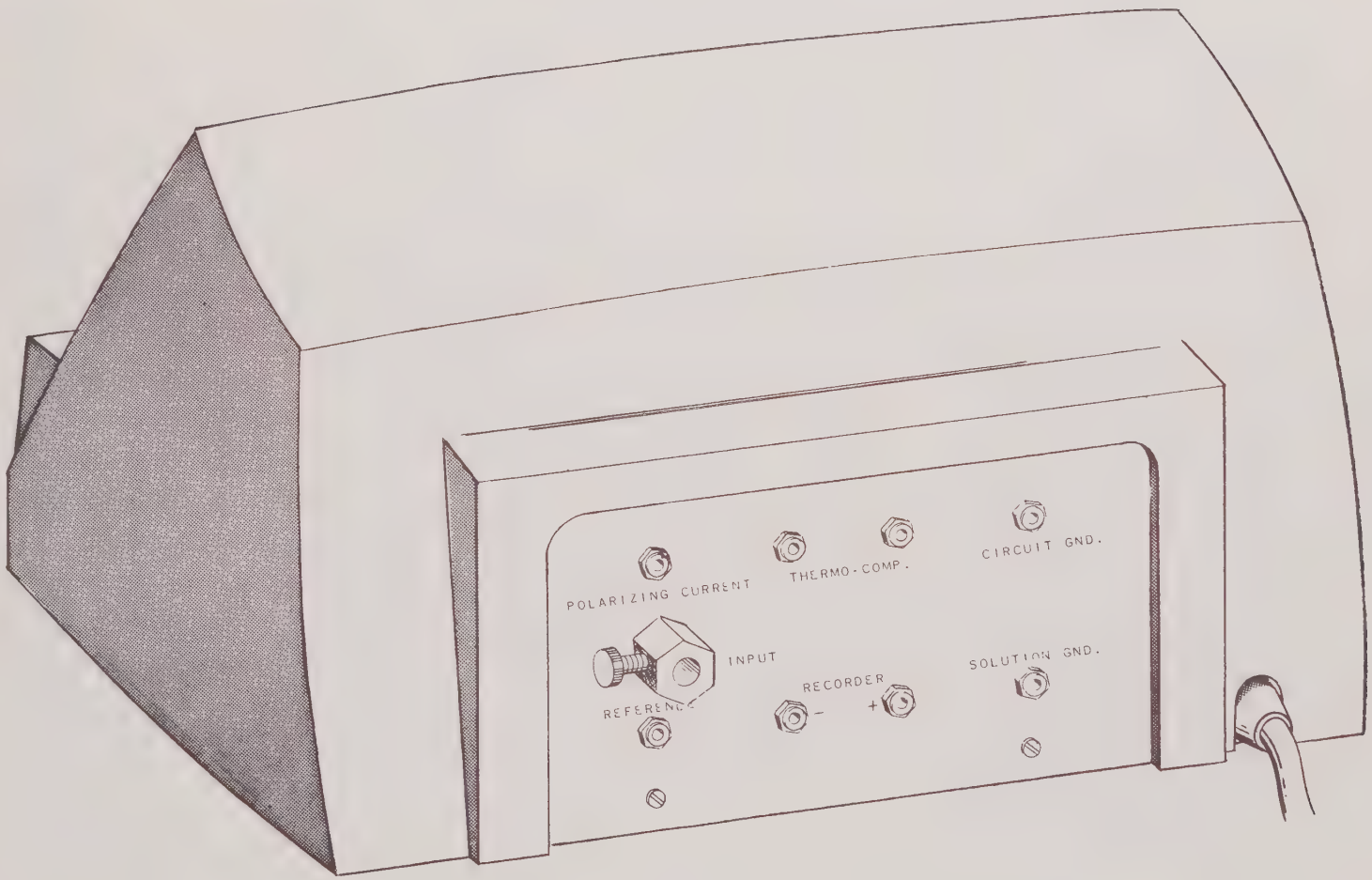


FIGURE 3. REAR VIEW OF ZEROMATIC

the instrument. The 9602 and 9603 ZEROMATICS are provided with a Swing-Arm Electrode Holder, designed to accommodate special small electrodes and a 5 ml beaker.

2.2.1 INSTALLATION ON 9600-9601 ZEROMATICS

To attach the Electrode Holder to a 9600 or a 9601 ZEROMATIC, invert the instrument and attach the Bracket to the bottom cover plate, as indicated in Figure 2, using the screws provided. Attach the Support Rod to the Bracket, using the nut provided, and slide the Electrode Holder onto the Support Rod.

Mount the Electrodes in the Holder, and connect the leads to the proper terminals on the rear of the instrument. If the Thermo-Compensator is to be used, mount this also in the Electrode Holder, and attach the leads to the proper terminals at the rear of the instrument.

2.2.2 INSTALLATION ON 9602-9603 ZEROMATICS

To attach the Swing-Arm Electrode Holder to a 9602 or a 9603 ZEROMATIC, invert the instrument and attach the Bracket to the bottom cover plate, as indicated in Figure 2, using the screws provided. Mount the Electrodes in the Holder, positioning the tips of the Electrodes about 1/16 inch apart. Connect the Electrode leads to the proper terminals at the rear of the instrument.

2.3 GROUND CONNECTIONS

2.3.1 Grounding the Instrument

To insure greatest stability of operation, connect the instrument case to a good earth ground. This connection may be made to either of the two screws at the lower edge of the Terminal Board at the rear of the Instrument. This case-to-ground connection should not be made, however, when the solution is grounded.

2.3.2 Solution Grounding

If the pH Meter and the sample solution are interconnected by any means other than the electrodes, it is impossible to measure pH accurately. This situation exists, for example, when the instrument is grounded through its power cord and the sample is in a metal container which is not isolated from ground. To avoid this situation when the sample cannot be isolated readily, use the BECKMAN 16988 Power-Cord Adapter (supplied) regardless of the type of outlet, and leave the ground lead from the Adapter disconnected. If the Electrodes are to be used in a grounded system, establish a connection between the test solution and the Solution Ground Terminal. Connection to the test solution may be made through metallic tubes or pipes in direct contact the solution, or, if an all-glass system is used, through platinum or other inactive conductor dipped into the solution itself. (See Figure 4.) Make the solution ground connection near the point at which the Electrodes are immersed in the test solution. When the solution is grounded, take care to insure that the instrument case is well insulated from ground.

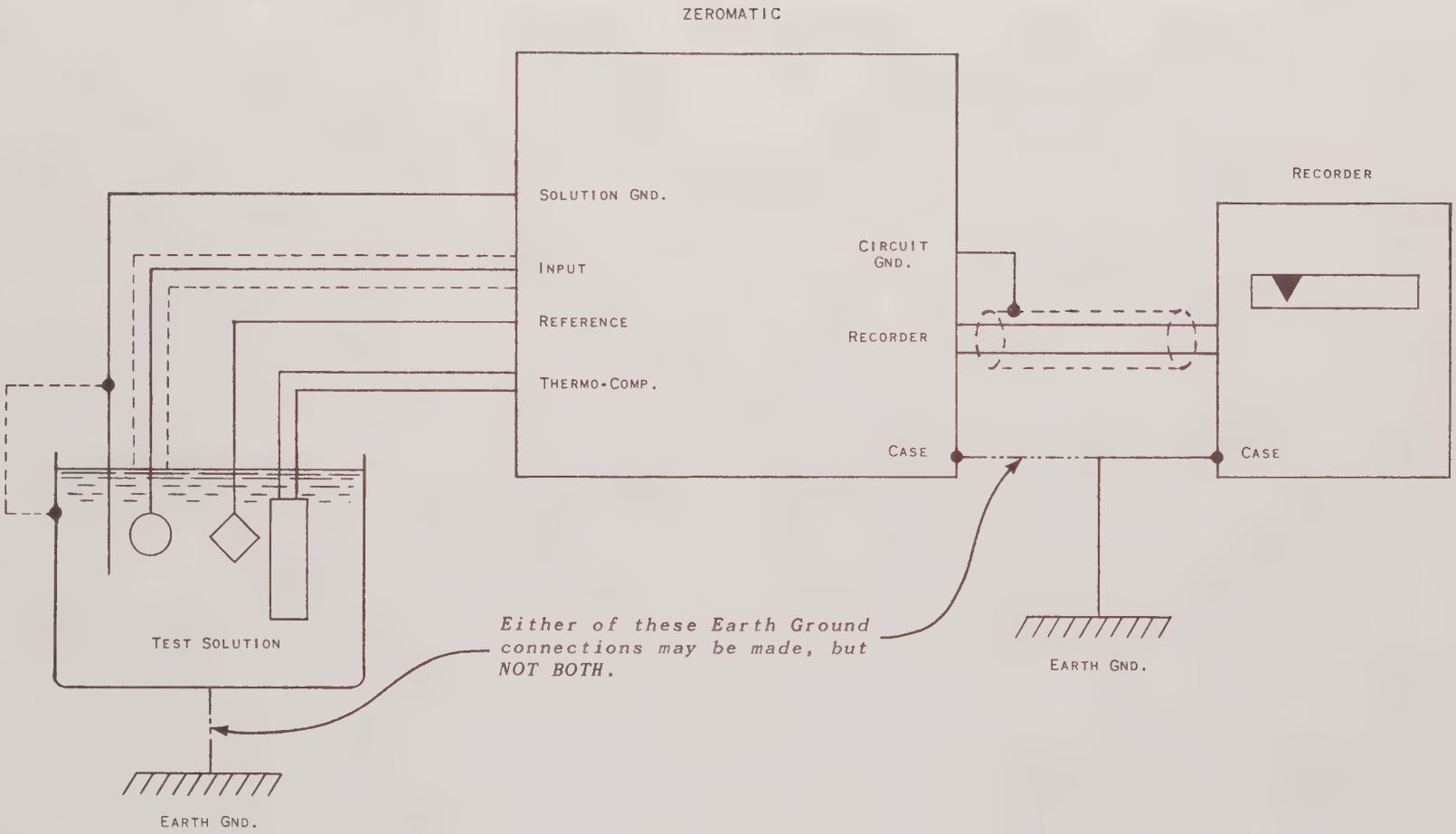


FIGURE 4. GROUNDING CONNECTIONS

SECTION 3

3. OPERATION

3.1 TEMPERATURE COMPENSATION.

Since the value of a pH unit is a function of the temperature, it is necessary to apply a temperature correction when making determinations with a pH Meter. The ZEROMATIC is designed to offer provision for making temperature adjustment in either of two ways: (1) Manual Temperature Compensation, and (2) Automatic Temperature Compensation, using the BECKMAN 39096 Thermo-Compensator.

3.1.1 Manual Temperature Compensation.

If measurements are made within 2 pH units of the buffer value, a 10°C temperature variation will result in an error of less than 0.07 pH. If measurements are made within 1.0 pH of the buffer value, the error will be less than 0.035 pH.

In making pH determinations using the ZEROMATIC without the Thermo-Compensator, determine the temperature of the solution (buffer or sample), and make the necessary temperature compensation, by manually setting the Temperature Adjustment Control (TEMP.) to the temperature of the solution. For routine laboratory work, when all samples are at constant room temperature, it is not necessary to re-adjust the Temperature Adjustment Control for each sample.

In order to minimize errors due to variations in temperature of samples and buffer solution, select the buffer with pH as close to that of the sample as possible. Buffer temperature should be as close as possible to temperature of sample.

3.1.2 Automatic Temperature Compensation.

In some instances sample solution temperatures may fluctuate so rapidly that continuous adjustment of the Temperature Adjustment Control becomes inconvenient and tedious. The BECKMAN 39096 Thermo-Compensator may be used with the ZEROMATIC to provide automatic temperature adjustment.

3.2 STANDARDIZING INSTRUMENT.

Standardize the instrument daily against a buffer solution of known pH. For most accurate work, check standardization of the instrument before and after each series of measurements.

The pH value of the buffer solution depends on the temperature of the solution at time of measurement. Always standardize with buffer at a temperature within 10°C of the temperature of the sample solution.

3.3 pH MEASUREMENTS WITHOUT THERMO-COMPENSATOR.

3.3.1 Standardization.

To standardize the ZEROMATIC when used without Thermo-Compensator, proceed as follows:

(1) Depress STANDBY push-button.

(2) Connect power cord to 115-volt a-c electrical outlet.

(3) Allow Amplifier to warm-up for two minutes.

(4) Immerse Electrodes (Reference and Glass) in buffer solution.

(5) Set Temperature Adjust Control (TEMP.) to temperature of buffer solution.

(6) Depress MAN. push-button.

(7) Depress READ push-button.

(8) Adjust Asymmetry Control (ASYMM.) until Meter needle indicates correct value for pH of buffer solution.

3.3.2 pH Measurements.

To determine sample pH, using the ZEROMATIC without Thermo-Compensator, follow the procedure outlined below:

(1) Standardize the instrument as indicated in Par. 3.3.1.

(2) Depress STANDBY push-button.

(3) Rinse Electrodes in distilled water.

(4) Immerse Electrodes in sample solution.

(5) Set Temperature Adjustment Control (TEMP.) to temperature of sample solution.

(6) Depress READ push-button and read pH value of sample solution from Meter.

IMPORTANT

When making Manual temperature corrections, Thermo-Compensator MUST NOT BE CONNECTED TO INSTRUMENT.

3.4 pH MEASUREMENTS WITH THERMO-COMPENSATOR.

3.4.1 Standardization.

To standardize the ZEROMATIC when used with Thermo-Compensator, proceed as follows:

(1) Depress STANDBY push-button.

(2) Connect power cord to 115-volt a-c electrical outlet.

(3) Allow Amplifier to warm-up for two minutes.

(4) Immerse Electrodes (Reference and Glass) and Thermo-Compensator in appropriate buffer solution.

(5) Depress AUTO. push-button.

(6) Depress READ push-button.

(7) Adjust Asymmetry Control (ASYMM.) until Meter needle indicates correct value of buffer solution.

3.4.2 pH Measurements.

To determine sample pH, using the ZEROMATIC equipped with the BECKMAN 39096 Thermo-Compensator, proceed as follows:

(1) Standardize the instrument as indicated in Par. 3.4.1.

(2) Depress STANDBY push-button.

(3) Rinse Electrodes and Thermo-Compensator in distilled water.

(4) Immerse Electrodes and Thermo-Compensator in sample solution.

(5) Depress READ push-button and read pH value of sample solution from Meter.

> NOTE
>
> Leave instrument connected to power line at all times, except when not to be used for extended periods. This will insure stable, trouble-free performance and will protect the instrument from adverse effect of excessive humidity. Depress STANDBY push-button when instrument is not in use.

3.5 MILLIVOLT MEASUREMENTS.

Millivolt measurements for oxidation-reduction reactions may be made with the ZEROMATIC. These measurements may be made either in the ±700 mv range, or in the 1400 mv span range. Measurement procedures are outlined in Paragraphs 3.5.1 and 3.5.2.

> NOTE
>
> When making Millivolt measurements with the ZEROMATIC, disconnect the Thermo-Compensator from the instrument. The manual Temperature Control is automatically disconnected when either of the Millivolt push-buttons is depressed.

3.5.1 Millivolt Measurements (700-0-700 Range).

When operated in the ±700 mv range, the ZEROMATIC has a fixed zero reading, the Asymmetry Control being inoperative. To make millivolt measurements in the 700-0-700 range, proceed as follows:

(1) Depress STANDBY push-button.

(2) Connect power cord to 115-volt a-c electrical outlet.

(3) Allow Amplifier to warm-up for two minutes.

(4) Immerse Electrodes in sample solution.

(5) Depress ±700 push-button.

(6) Depress READ push-button and read millivolt value on 700-0-700 Meter Scale (red scale).

3.5.2 Millivolt Measurements (1400-mv span range).

The sensitivity of the ZEROMATIC when operated in the 1400-mv span range is the same as in the ±700 range. In the 1400-mv range, the Asymmetry Control is operative, and may be used to set the zero millivolt position of the Meter to any desired point on the scale; each scale division represents 100 mv.

The determination of reaction potential changes is facilitated by use of the 1400-mv span range of the ZEROMATIC; the entire course of a reaction may often be observed without the necessity of switching instrument ranges.

For example, if a reaction potential changes from -100 to +800 millivolts, the instrument "zero" may be set at 11 on the pH scale (prior to immersion of the Electrodes in the solution). The Meter will then indicate -300 to +1100 millivolts, permitting direct observation of potential changes throughout the reaction. A convenient method of determining a suitable "zero" point is to set the instrument "zero" at the position corresponding to the highest (+) millivolt value desired.

To make millivolt measurements in the 1400-mv span range, follow the procedure outlined below:

(1) Depress STANDBY push-button.

(2) Connect power cord to 115-volt electrical outlet.

(3) Allow Amplifier to warm-up for two minutes.

(4) Immerse Electrodes in sample solution.

(5) Depress AUTO. and READ push-buttons.

(6) Adjust Asymmetry Control (ASYMM.) to set Meter to desired "zero" point.

(7) Depress 1400 push-button, and read millivolt value as measured from "zero" point set in (6) above.

3.6 DETERMINING ASYMMETRY POTENTIAL.

For most purposes it is not necessary to determine the actual value of the asymmetry potential of the Electrode system. The standardization procedures outlined in Paragraphs 3.3.1 and 3.4.1 provide automatic compensation for the characteristic asymmetry potential of the Electrode system being used.

If it is desired, for special applications, to determine the asymmetry potential of the Electrode system, this may be accomplished by following the procedure outlined below:

(1) Depress STANDBY push-button.

(2) Connect power cord to 115-volt a-c electrical outlet.

(3) Allow Amplifier to warm-up for two minutes.

(4) Immerse electrodes (reference and glass) in pH 7.00 buffer solution at or near 25°C.

(5) Depress ±700 push button.

(6) Depress READ push button and read asymmetry potential on 700-0-700 Meter Scale (red scale).

3.7 POLARIZING CURRENT.

The ZEROMATIC is useful for determining titration end-points for Karl Fischer titrations and similar reactions. Use of the ZEROMATIC eliminates the necessity for evaluating color changes at the end-point of a reaction, and makes possible determinations in dark or colored solutions.

A polarizing current of about 10 microamperes is available at the Terminal Board at the rear of the instrument for use when making Karl Fischer and similar titrations. To apply this polarizing current to the electrodes, proceed as follows:

(1) Disconnect the Glass Electrode from the Input Terminal on the Terminal Board.

(2) Insert the BECKMAN 700 Terminal Connector* into the Input Terminal to adapt this terminal for phone-tipped leads.

(3) Plug the phone-tip end of the BECKMAN 5083 Polarizing Jumper* into the Polarizing Current terminal on the Terminal Board of the instrument.

(4) Connect a Beckman Metallic Electrode to the 700 Terminal Connector and fasten the spring clip of the polarizing jumper onto the protruding portion of the electrode phone-tip lead end.

(5) Connect a second Beckman Metallic Electrode to the reference terminal.

(6) Depress ±700 and READ Push-Buttons.

(7) Proceed with titration as in millivolt measurements.

When Meter registers a sudden increase (about 200 mv), end-point (back titration) has been reached. Direct titration end-point is indicated when Meter registers a sudden decrease. For further information refer to Application Data Sheets Z-80-MI, pH-79-MI, and pH-83-MI.*

*Available through your BECKMAN Dealer.

SECTION 4

4. RECORDER ATTACHMENT

4.1 RECORDER SPECIFICATIONS.

The ZEROMATIC may be operated with a standard potentiometer-type recorder or with a standard current-type recorder. Recorder specifications are as follows:

4.1.1 Potentiometer-type Recorder.

(1) Sensitivity of 200 millivolts or less.

(2) Zero at center scale (or use zero-shifting network). See Figure 4A.

4.1.2 Current-type Recorder.

(1) Sensitivity of 200 microamperes (more sensitive recorders may be shunted to 200 microamperes).

(2) Zero at center scale (or use zero-shifting network).

(3) Recorder resistance less than 1000 ohms.

4.2 CONNECTING POTENTIOMETER-TYPE RECORDER.

4.2.1 Installing Recorder Resistor

If the ZEROMATIC is to be operated with a potentiometer-type recorder, install a suitable Recorder Resistor in the instrument. Recorder Resistors (Refer to Para. 6.2) are available through your BECKMAN Dealer for use with recorders of various sensitivities. For method of determining proper Resistor values, refer to Paragraph 6.2.2.

To install the Recorder Resistor in the ZEROMATIC and connect the Recorder to the instrument, proceed as follows:

(1) Turn instrument on its back, and remove the four corner screws from the Bottom Cover Plate. (See Figure 2.)

(2) Turn instrument right side up, carefully lift plastic case off the instrument, and set case aside.

(3) Locate the Recorder terminals on the inside of the Terminal Board at the rear of the instrument.

(4) Cut out the shorting strap across the Recorder terminals. (This is installed so that the ZEROMATIC will operate properly if Recorder is not to be used.)

(5) Solder Recorder Resistor across Recorder terminals.

(6) Replace plastic case and attach to Bottom Cover Plate by replacing four screws removed in (1).

> NOTE
>
> It is not necessary to remove the Recorder Resistor if the Recorder is to be disconnected and the instrument operated independently.

4.2.2 Connecting Recorder

(1) Install phone-tips on the Recorder leads.

> NOTE
>
> Solderless phone-tips such as Insuline Corp of America Nos. 7526, 7530, or 359 (or equivalent) may be used.

(2) Connect Recorder leads to Recorder terminals on the Terminal Board at the rear of the instrument.

(3) Ground the Recorder case to a good earth ground.

NOTE

If the Recorder is affected by a-c pick-up, evidenced by random deviations of the indicator, shield the Recorder leads, and connect the shield to the Circuit Ground Terminal on the instrument. Shield must be insulated from earth ground.

4.3 CONNECTING CURRENT-TYPE RECORDER.

4.3.1 Preparing Instrument

To connect a current-type Recorder to the ZEROMATIC, proceed as follows:

(1) Turn instrument on its back and remove the four corner screws from the Bottom Cover Plate. (See Figure 2.)

(2) Turn the instrument right side up, carefully lift plastic case off the instrument, and set case aside.

(3) Locate the Recorder Terminals on the inside of the Terminal Board at the rear of the instrument.

(4) Cut out the shorting strap across the Recorder Terminals. (This is installed so that the ZEROMATIC will operate properly if Recorder is not to be used.)

NOTE

A Recorder Resistor is NOT required when the ZEROMATIC is operated with a current-type Recorder.

(5) Replace plastic case and attach to Bottom Cover Plate by replacing screws removed in (1).

NOTE

If current-type Recorder is disconnected from the ZEROMATIC and the instrument operated independently, short the Recorder Terminals on the Terminal Board at the rear of the instrument.

4.3.2 Connecting Recorder

(1) Install phone-tips on Recorder leads.

> NOTE
>
> Solderless phone-tips such as Insuline Corp of America Nos. 7526, 7530, or 359 (or equivalent) may be used

(2) Connect Recorder leads to Recorder terminals on the Terminal Board at the rear of the instrument.

(3) Ground the Recorder case to a good earth ground.

> NOTE
>
> If the Recorder is affected by a-c pick-up, evidenced by random deviations of the indicator, shield the Recorder leads, and connect the shield to the Circuit Ground Terminal on the instrument. Shield must be insulated from earth ground.

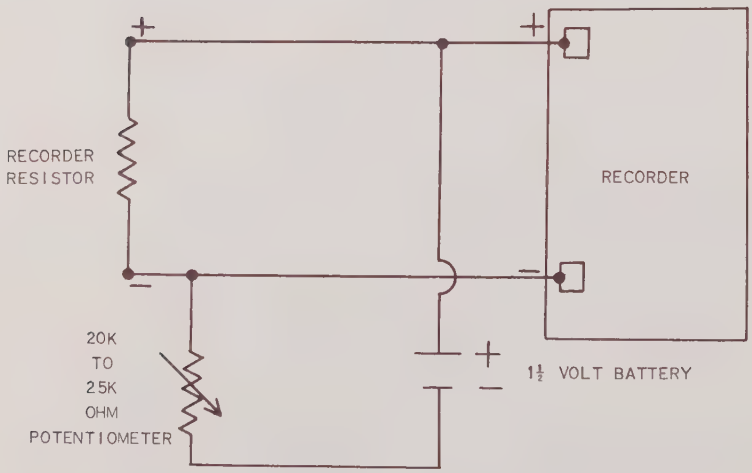


FIGURE 4A.
CIRCUIT FOR SHIFTING ZERO POINT
ON NON-ZERO-CENTER RECORDER

SECTION 5

5. CIRCUIT OPERATION

5.1 DESCRIPTION.

In order to facilitate description of the functions of the various portions of the ZEROMATIC Amplifier circuit, the various parts of the instrument are considered separately in the following paragraphs. The circuit diagram of the instrument is given in Figure 11; in addition, generalized diagrams for several of the individual portions of the circuit are presented.

5.1.1 pH Measuring Amplifier.

The pH Measuring Amplifier consists of a three-stage d-c amplifier (utilizing a 5886 Electrometer Tube and a 12AU7 Twin Triode Tube). The circuit employs negative voltage feedback to stabilize gain. A Balance Control is provided to establish the input bias condition; this Control is used for initial circuit adjustment, and for re-adjusting the circuit whenever tubes are replaced. The essential parts of the circuit are shown in Figure 5.

5.1.2 Corrector Amplifier.

The Corrector Amplifier is a four-stage d-c amplifier with negative voltage feedback. Two of the stages of the Corrector Amplifier are common with those of the pH Measuring Amplifier. (See Figures 7 and 7A.)

The Corrector Amplifier is operative only when the Relay is closed. The feedback part of the Amplifier maintains the input grid of the 5886 Electrometer Tube at constant potential while it furnishes energy to the storage capacitor C1. At the end of the corrector cycle, when the relay opens, C1 is charged to a voltage equal to the grid-to-ground potential of the 5886 Tube.

The circuit arrangement is such that this is the grid-to-ground potential of the pH Measuring Amplifier. When the Relay opens, C1 is connected to the grid circuit of the pH Measuring Amplifier in such a manner that the signal input terminal is maintained at ground potential. Thus, regardless of input tube bias drift, the input to the Amplifier is maintained at ground potential.

The Relay is pulsed once each second, causing the Corrector Amplifier to be operative for about .015 second. In effect, the circuit is automatically "zeroed" once each second. A filter in the output stage of the

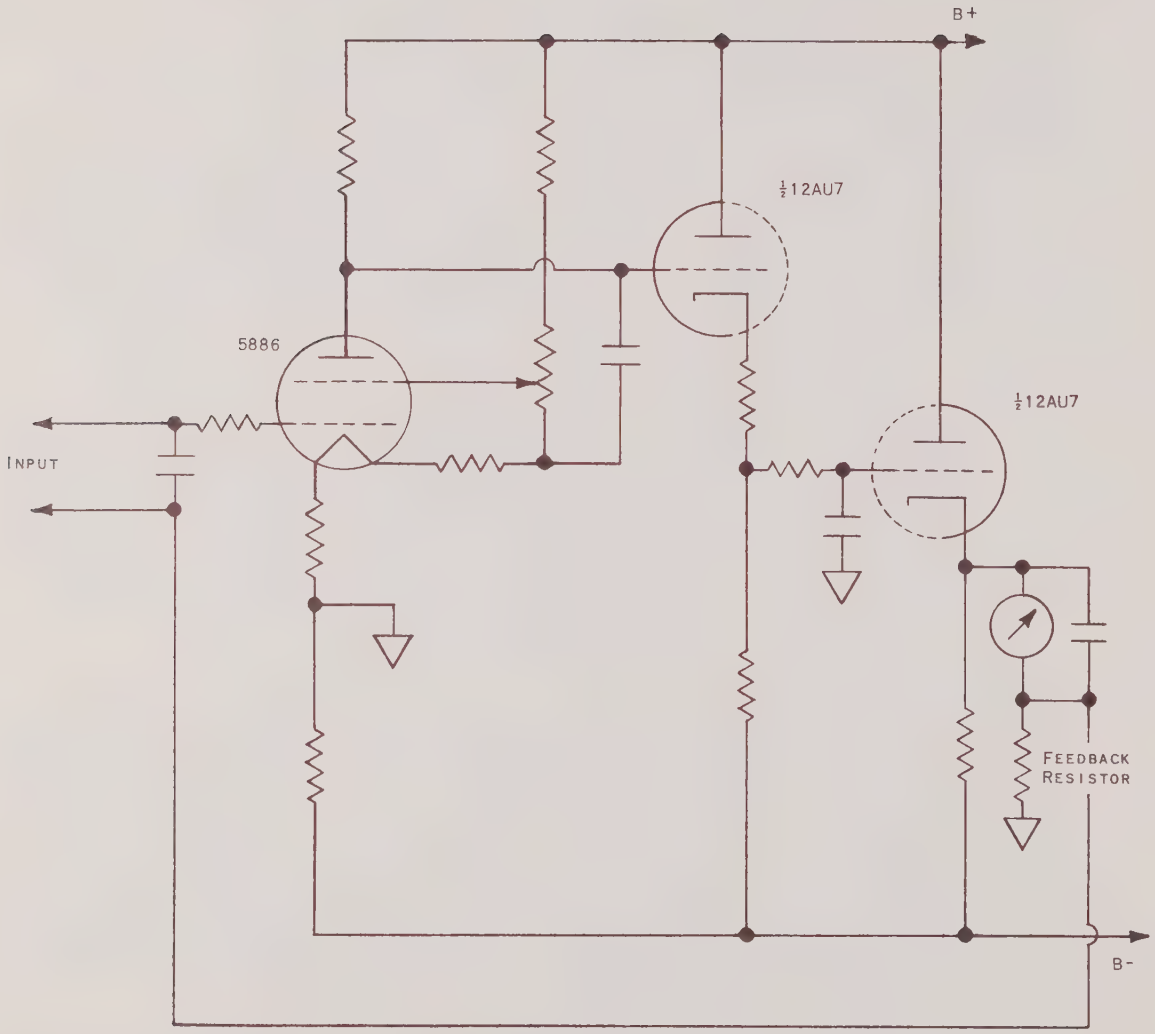


FIGURE 5. pH MEASURING AMPLIFIER CIRCUIT

pH Measuring Amplifier removes Corrector Amplifier pulses from the output circuit.

5.1.3 Relay Drive Circuit.

A 5823 Gas Trigger Tube is employed to pulse the Relay coil. (See Figure 10.) In this drive circuit, R28 and C14 constitute a low-frequency oscillator which is activated by the starter of the 5823 Tube. When this tube fires, C15 is discharged through the Relay coil, effecting a short dwell of the contacts.

5.1.4 Output Circuit.

A signal at the input of the Amplifier causes a voltage change at the cathode of the output tube. Current then flows through the Meter and the feedback resistor to circuit ground. (See Figure 6.) The voltage developed across the feedback resistor is applied to the Reference Electrode as negative voltage feedback.

When the voltage across the feedback resistor reaches a value equal to the voltage signal between the Glass and Reference Electrodes, the Amplifier maintains steady current in the output circuit. The circuit component values are such that the Meter indication is directly proportional to the signal voltage. As the Meter and Recorder terminals are outside the feedback point, the actual resistance of the Meter and the Recorder Resistor do not affect Meter accuracy.

The feedback resistor is changed for each type of measurement. For pH determinations with manual temperature control, the total resistance is varied by adjusting the Temperature Adjustment Control. For pH determinations with automatic temperature compensation, a special resistor (the Thermo-Compensator) is placed in the test solution near the Electrodes. This resistor is temperature-sensitive, and changes its resistance with changes of solution temperature. To insure accurate millivolt measurements, temperature-stable resistors are employed.

The Asymmetry Control may be used to compensate for minor variations between Electrode systems; these variations manifest themselves as a voltage discrepancy between the Electrode potential and the true pH potential. To correct for this, the Asymmetry Control circuit provides a variable biasing current to the output circuit. This current flows through the Meter and Recorder circuits; it does not flow through the feedback resistor.

5.2 REGULATED POWER SUPPLY.

The Power Supply of the ZEROMATIC is a regulated supply utilizing a 5651 Voltage Reference Tube, a single voltage amplifier stage and a series Regulator Tube. The B- return is arranged so that the B supply current holds the Relay closed when the instrument is at STANDBY. The regulated voltage is not affected by the Relay hold-down device.

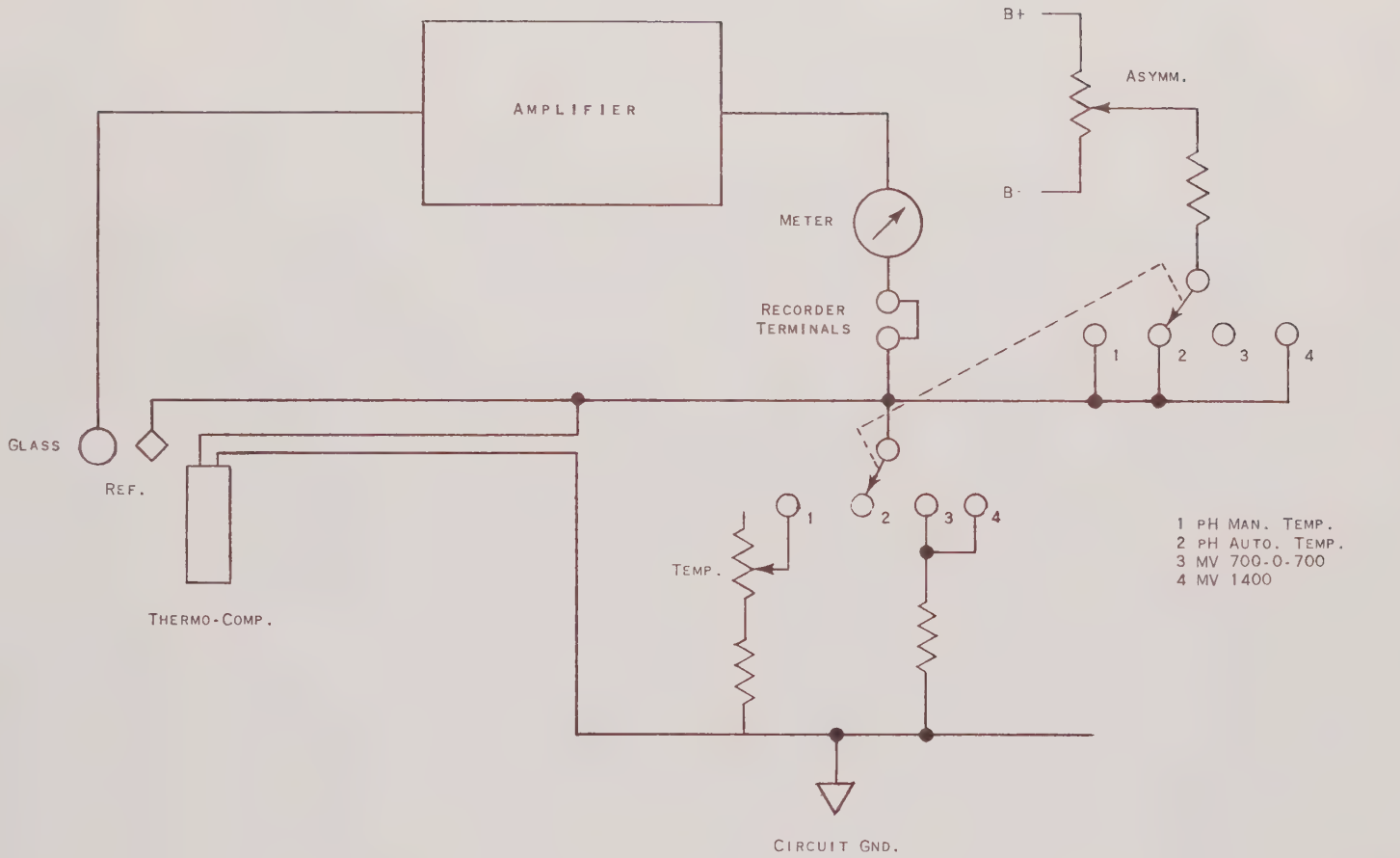


FIGURE 6. OUTPUT CIRCUIT

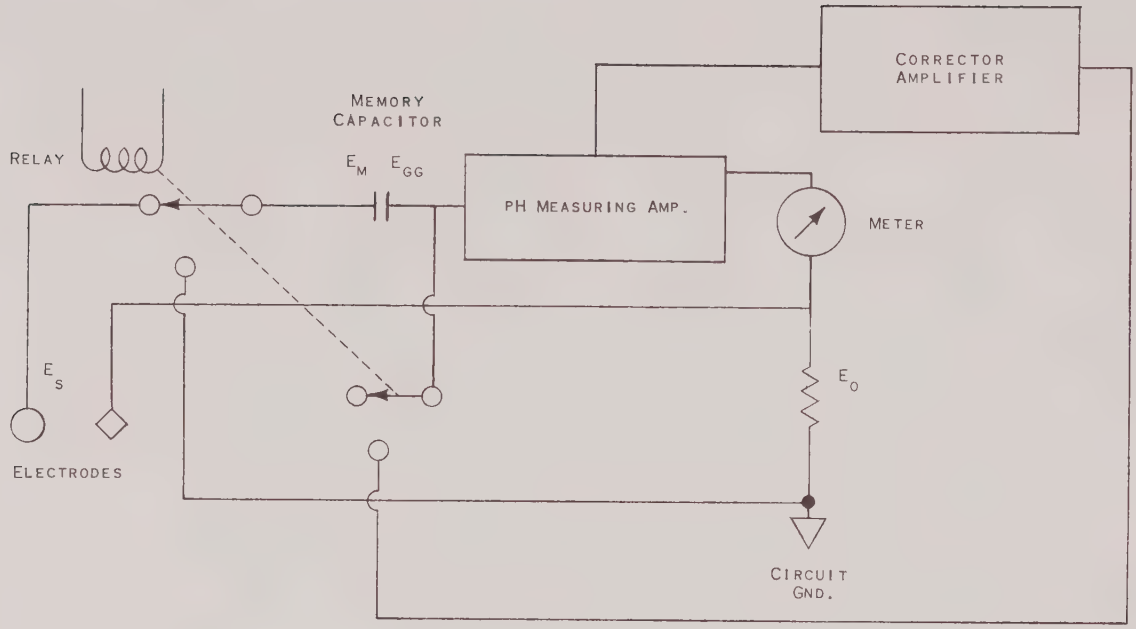


FIGURE 7. NORMAL CIRCUIT - MEASURING pH
ZEROMATIC AMPLIFIER

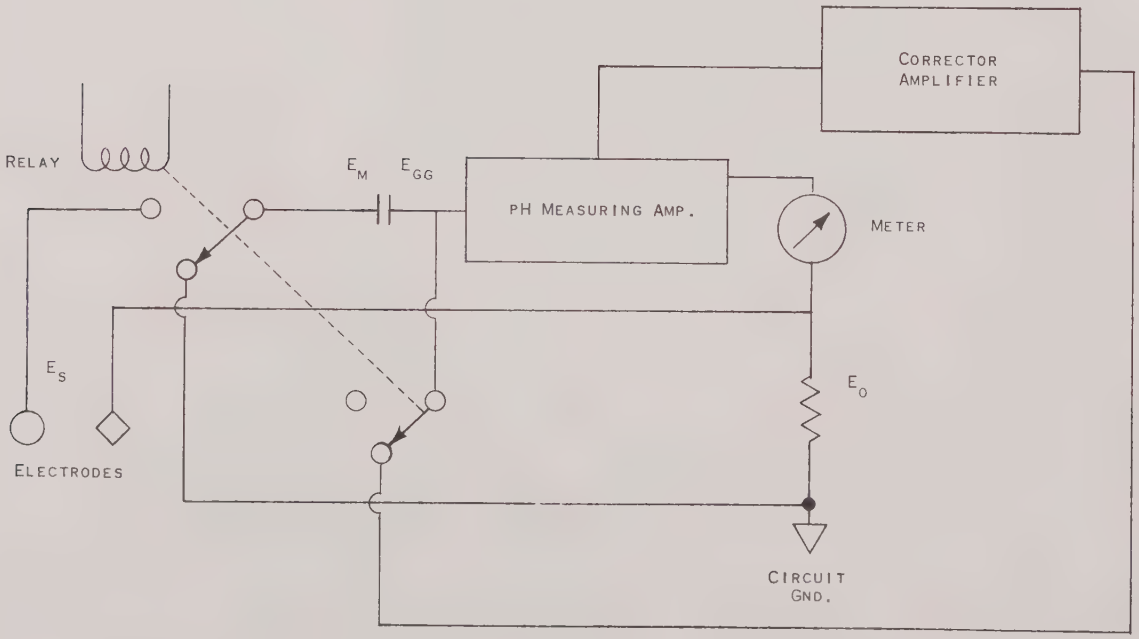


FIGURE 7A. CORRECTOR CYCLE
ZEROMATIC AMPLIFIER

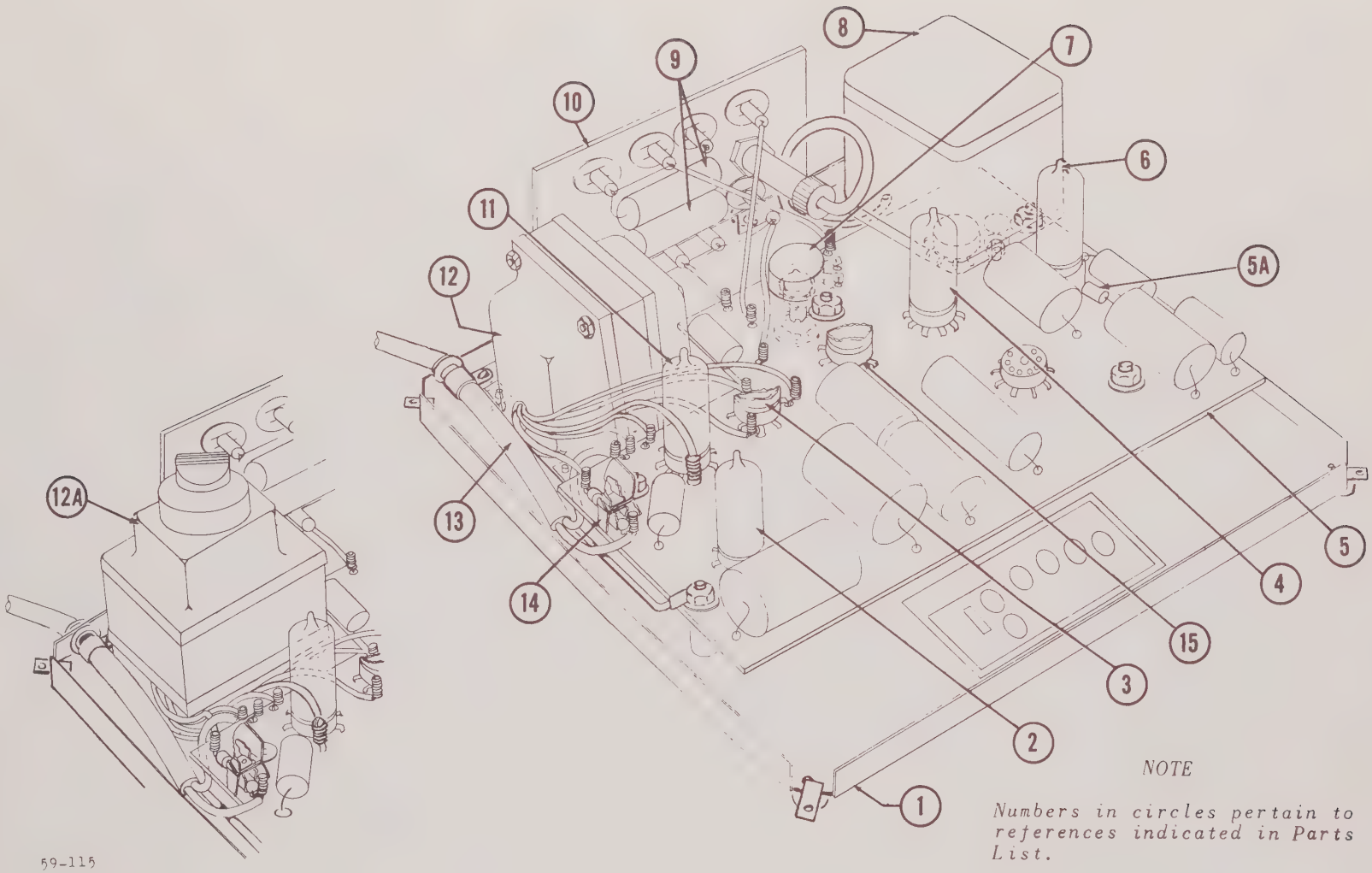
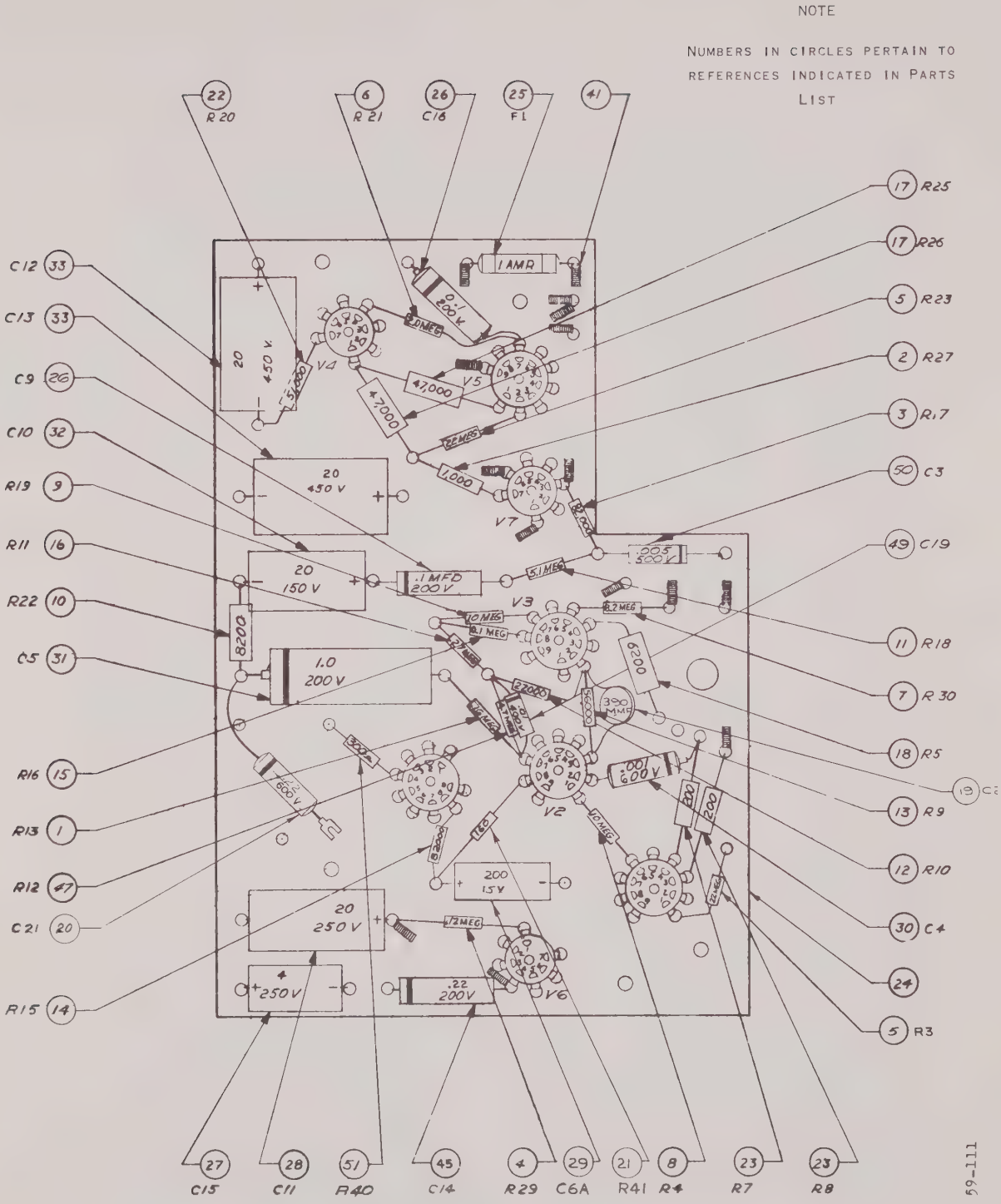


FIGURE 8. BOTTOM PLATE ASSEMBLY



TOP VIEW
COMPONENT LAYOUT

FIGURE 9. CIRCUIT BOARD ASSEMBLY

NOTE

NUMBERS IN CIRCLES PERTAIN TO REFERENCES INDICATED IN PARTS LIST

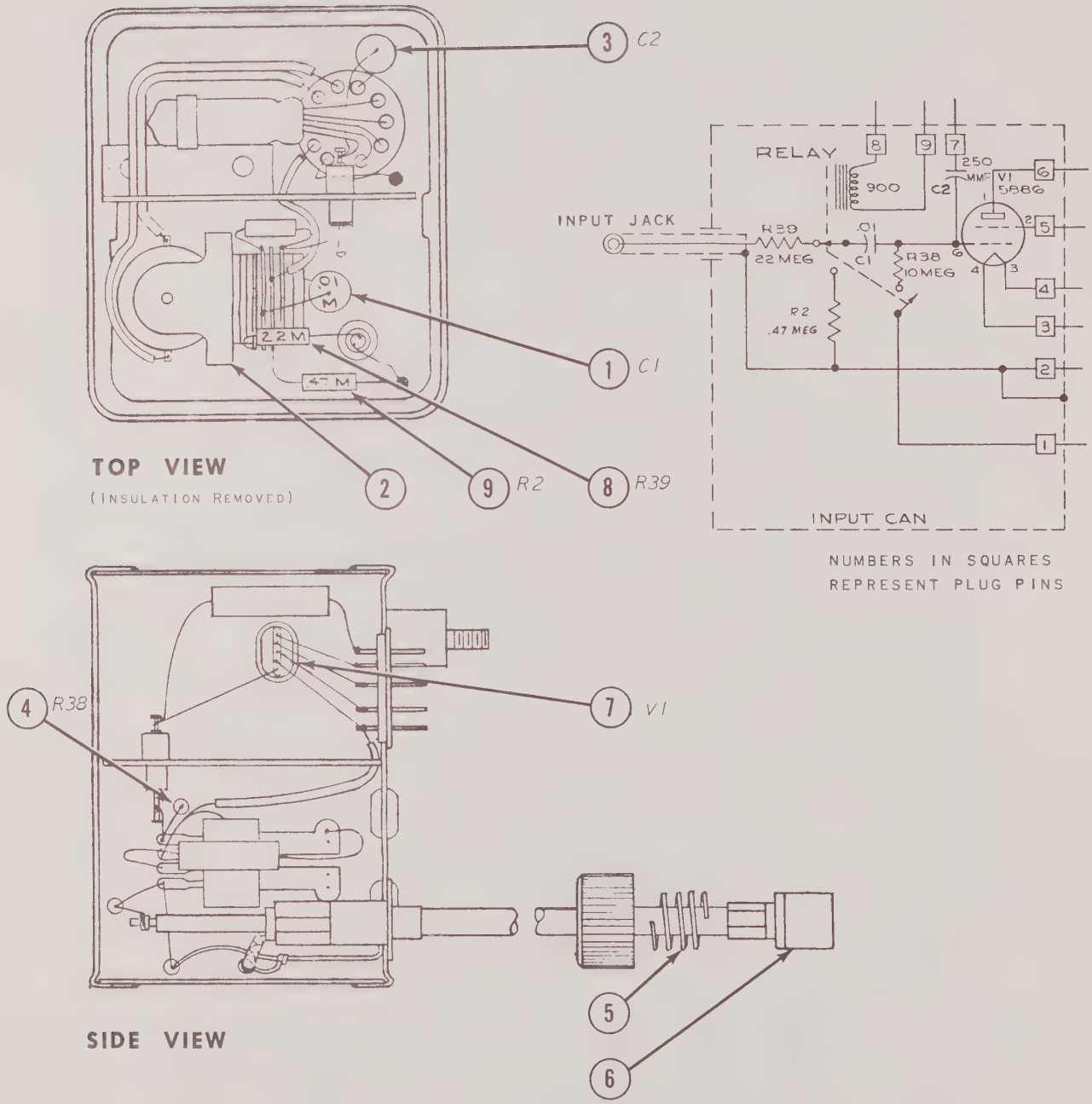


FIGURE 10. RELAY CAN ASSEMBLY

59-22

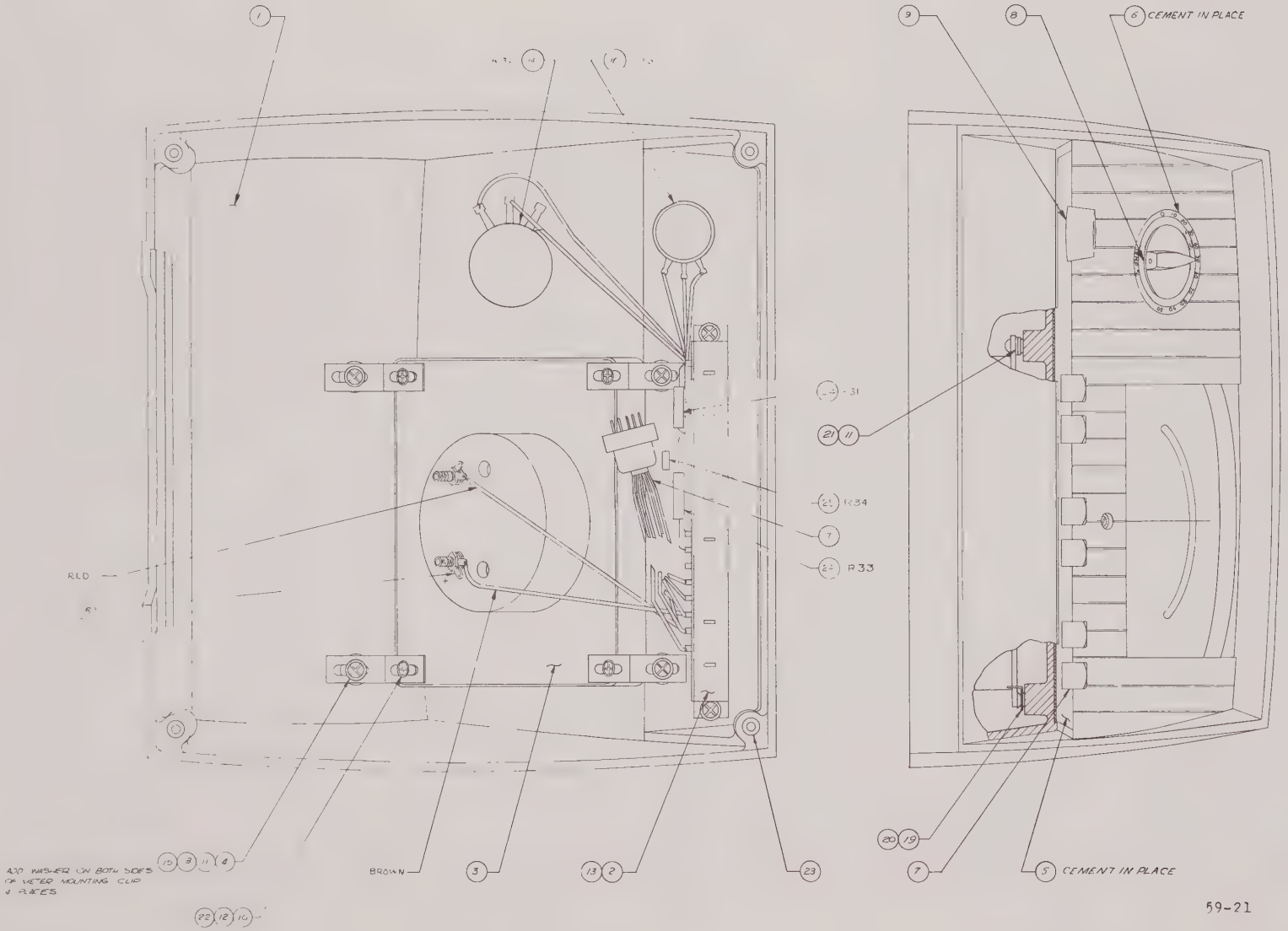


FIGURE 10A. CASE ASSEMBLY

5.3 FUNCTION OF THE ZEROMATIC CIRCUIT.

When the ZEROMATIC Amplifier Circuit is operating in its normal condition, with the Corrector Amplifier inoperative, the Meter indicates the potential of the pH Electrodes. (See Figure 7). The Memory Capacitor can be considered as a battery, having a constant potential during the period when the Amplifier is indicating the input signal.

The Meter indicates the voltage E_o, which is the sum of the voltages E_s, E_m, and E_{gg}. In a conventional d-c amplifier, the voltage E_m is nonexistent or equal to zero. For the moment, consider E_m equal to zero; the Meter, indicating E_o, is in error by the voltage E_{gg}. Thus, the Meter gives an erroneous reading. (In a conventional d-c amplifier, E_{gg} is made equal to zero by "zeroing" the amplifier.)

The ZEROMATIC Amplifier measures the value of E_{gg}, and applies this voltage to the circuit in such a manner that the sum of the voltages E_{gg} and E_m are zero. Thus the Amplifier receives and transmits to the Meter only the Electrode voltage E_s.

When an error voltage E_{gg} is present in the circuit, the Corrector Amplifier charges the Memory Capacitor to this same voltage. When the ZEROMATIC circuit returns to normal, as indicated in Figure 7, the voltage on the Memory Capacitor balances the voltage E_{gg}; only the signal voltage from the Electrodes reaches the pH Measuring Amplifier and is indicated by the Meter.

As the Corrector Amplifier performs this function once each second, the pH Measuring Amplifier is required to be stable for only one second.

SECTION 6

6. ACCESSORIES

6.1 THERMO-COMPENSATOR.

The BECKMAN 39096 Thermo-Compensator, available through your BECKMAN Dealer, facilitates pH determinations with the ZEROMATIC by providing automatic temperature compensation. The method of making pH determinations with the ZEROMATIC equipped with the Thermo-Compensator is described in Par. 3.4. For complete description of the 39096 Thermo-Compensator, refer to Instruction Manual 532.

6.2 RECORDER RESISTORS.

A suitable Recorder Resistor must be installed in the ZEROMATIC if the instrument is to be operated with a Potentiometer-type Recorder. (See Par. 4.2.1.)

6.2.1 Description.

The following Recorder Resistors are available through your BECKMAN Dealer for use with the ZEROMATIC and potentiometer-type Recorders.

Recorder Sensitivity (Millivolts)	Description	BECKMAN Part No.
10 mv	Resistor, 50 ohms ±1%, 1/4 W, Cinema Type JR-1E	17220
35 mv	Resistor, 175 ohms ±1%, 1/4 W, Cinema Type JR-1E	5931
50 mv	Resistor, 250 ohms ±1%, 1/4 W, Cinema Type JR-1E	5932
70 mv	Resistor, 350 ohms ±1%, 1/4 W, Cinema Type JR-1E	5933
100 mv	Resistor, 500 ohms ±1%, 1/4 W, Cinema Type JR-1E	17223

6.2.2 Determination of Resistor Value.

The resistance required for proper Recorder operation may be computed from the Recorder sensitivity and the sensitivity of the Meter in the ZEROMATIC.

Example:

Meter Sensitivity 200 microamperes full scale
Recorder Sensitivity 50 mv full scale

Applying Ohm's Law:

$$R(\text{ohms}) = \frac{E\ (\text{volts})}{I\ (\text{amps})}$$

$$= \frac{\text{Recorder Sensitivity (volts)}}{\text{Meter Sensitivity (amps)}}$$

$$= \frac{50 \times 10^{-3}}{200 \times 10^{-6}}$$

$$= .25 \times 10^{3}$$

$$= 250$$

Therefore, for a Recorder with sensitivity of 50 millivolts, a resistor with a value of 250 ohms is required. Resistor tolerance of 1% will suffice for most applications.

6.3 SWING-ARM ELECTRODE HOLDER

The Swing-Arm Electrode Holder is available through your BECKMAN Dealer as an accessory to be attached to the 9600-9601 ZEROMATIC. The Swing-Arm Assembly is offered in two different versions to suit various needs:

22340 Swing-Arm Adapter Kit. This Kit consists of the Swing-Arm Electrode Holder, a 5 ml beaker and the necessary fittings for attaching the Holder to the ZEROMATIC. This Kit does not include the small Electrodes required for operation of the ZEROMATIC with the Swing-Arm Electrode Holder.

24930 Swing-Arm Assembly. This consists of the Swing-Arm Electrode Holder, necessary fittings for attaching to the ZEROMATIC, small General-purpose Electrode, small Reference Electrode, and a 5 ml beaker.

SECTION 7

7. SERVICE AND MAINTENANCE

7.1 GENERAL.

The ZEROMATIC is designed to give long and accurate performance with a minimum of maintenance. If the need for maintenance is indicated, use the procedures outlined in the following paragraphs to check the functioning of the instrument and its related components.

7.1.1 Preliminary Check.

Determine whether the apparent malfunction is in the internal electrical components or in the external components (e.g., Electrodes or buffer). If the Meter cannot be standardized against the buffer solution with the pair of Electrodes in use, substitute a set of Electrodes known to be good. This procedure will either correct the faulty operation, or indicate that the source of trouble is not in the Electrodes.

If a spare set of Electrodes is not available, the following procedure may be used to locate the difficulty:

(1) Disconnect the Electrodes and insert the BECKMAN 700 Terminal Connector and the BECKMAN 8980 Short-Circuit Strap into the Electrode jacks, simulating Electrodes for test purposes.

(2) Depress pH MAN and READ push buttons.

(3) Adjust the Asymmetry Control (ASYMM.) to bring the Meter needle to 7 on the pH scale.

(4) If the Meter needle balances at 7 pH, the internal components of the ZEROMATIC are functioning properly, and the source of trouble is in the Electrodes or in the buffer.

(5) If the Meter needle cannot be brought to balance at 7 pH, the trouble is within the instrument, and a check of the internal components should be made. (See Par. 7.3.)

7.2 Checking External Components.

Experience indicates that many instances of faulty operation are due

to malfunctions in one or more of the external components, i.e., the Glass Electrode, the Reference Electrode, or the buffer solution.

7.2.1 Glass Electrode.

If damaged in any way, the Glass Electrode must be replaced. Keep the Electrode clean for best results. An effective method is to rinse the Electrode in distilled water after each measurement and then wipe with absorbent tissue or cloth.

Some industrial solutions tend to deposit a film of material on the Electrode, which renders its action sluggish. Water or a dilute solution of acid or alkali should be used to remove any visible film. See instruction sheet supplied with each Electrode for complete maintenance instructions.

7.2.2 Reference Electrode.

Replace the Reference Electrode if the internal assembly is cracked or broken, or if the internal solution becomes contaminated. This Electrode must be kept nearly filled with saturated KCl solution. Clean the Reference Electrode in distilled water, and dry with absorbent tissue after each measurement. See instruction sheet supplied with the Reference Electrode for complete instructions.

7.2.3 Buffer Solution.

If contamination of the buffer solution is evident or suspected, replace with fresh BECKMAN Buffer Solution. To insure accuracy of pH measurements, check the instrument with buffer solutions of two different pH values.

7.3 REPLACEMENTS AND ADJUSTMENTS.

7.3.1 Replacing Relay Can Assembly.

If the Relay becomes inoperative (See Par. 7.4) replace the Relay Can Assembly. As this unit is sealed and can be serviced properly only by a qualified technician, it is advisable to replace the entire unit rather than attempt repair.

To replace the Relay Can Assembly, proceed as follows:

(1) Disconnect the cable between the Relay Can Assembly and the Input Jack. (See Figure 8.)

(2) Remove the nut from the hold-down stud on the Relay Can Assembly. This nut may be reached through the access hole near the right rear corner of the Bottom Cover Plate. (See Figure 2).

(3) Remove the Relay Can Assembly from its socket.

(4) Install new Relay Can Assembly in socket.

(5) Replace nut on hold-down stud.

(6) Connect cable between Relay Can Assembly and Input Jack.

7.3.2 Adjusting Balance Control.

The Balance Control is used to readjust the input-to-ground potential when Amplifier tubes of Relay Can Assembly are replaced (See Figure 2). The function of the Balance Control is to adjust the voltage across capacitor C1 to a minimum; this insures the best Amplifier performance.

To adjust the Balance Control, proceed as follows:

(1) Lock down both the ±700 push-button and the AUTO. push-button.

(2) Release both the STANDBY and READ push-buttons.

(3) Adjust the Balance Control very slowly until the meter needle comes, and stays, on scale.

7.4 TROUBLE-SHOOTING

If apparent malfunction has been localized in the internal electrical components (see Par. 7.1.1), the procedures outlined below will serve in most instances to locate and correct the trouble. In the event that difficulties encountered are not covered by these instructions, please communicate with your BECKMAN dealer or with the nearest BECKMAN Service Office, giving the serial number of the instrument and a brief outline of the symptoms.

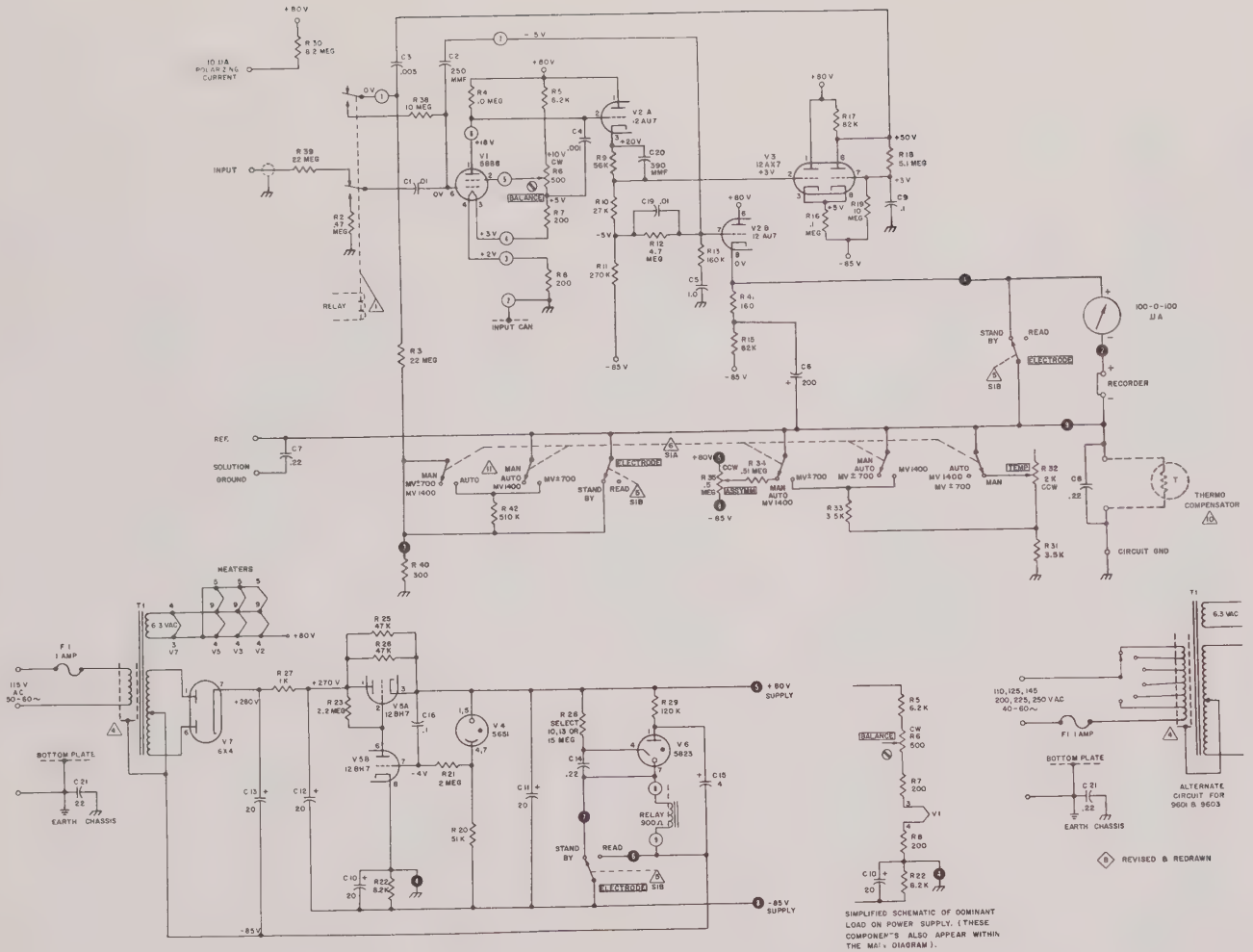
TROUBLE	REMEDY
1. Fuse blows out when instrument connected to electrical source	Replace Fuse; replace V7
2. No Meter needle movement; V4 does not glow	Replace V7
3. Relay not operating; V6 flashing	Replace V6

	TROUBLE	REMEDY
4.	Relay operating too fast or too slow (should pulse between .8 and 1.2 secs)	Replace R-28 with resistor having value of 10, 13, or 15 Megohms, whichever will yield correct pulse rate. If not effective, replace V6 and repeat R28 substitution.
5.	V6 Not flashing	Replace V6
6.	Relay not operating; replacing V6 not effective	Replace Relay Can Assembly
7.	Meter needle off scale to the right; Relay operating faster than normal	Replace Relay Can Assembly
8.	Meter needle off scale to the left	Replace V2
9.	Large pulsations of Meter needle (.2 pH or greater) as Relay operates	Replace V3
10.	Large pulsations of Meter needle (.2 pH or greater) as Relay operates; Relay operating at rate much slower than normal	Replace V5
11.	Meter needle jumps wildly when input terminals are shorted	Replace Relay Can Assembly
12.	Meter needle moves erratically when Asymmetry Control is adjusted	Rotate control knob rapidly several times to remove any dirt from contact surfaces; if trouble persists, replace R35

REPLACEMENT PARTS LIST

SYMBOL	REFERENCE	DESCRIPTION	BECKMAN PART
	Fig. 8	BOTTOM PLATE ASSEMBLY	16617
V4	2, Fig. 8	Tube, Electronic, 5651	173
V7	3, Fig. 8	Tube, Electronic, 6X4	12013
V2	4, Fig. 8	Tube, Electronic, 12AU7	12015
V3	15, Fig. 8	Tube, Electronic, 12AX7	15093
V5	11, Fig. 8	Tube, Electronic, 12BH7	23742
V6	6, Fig. 8	Tube, Electronic, 5823	16619
R6	7, Fig. 8	Potentiometer, 500 ohms	15134
	10, Fig. 8	Terminal Board Assembly	16612
C7, C8	9, Fig. 8	Capacitor, .22 mfd	16629
TI	12, Fig. 8	Transformer (9600 pH Meter)	16613
TI	12-A, Fig. 8	Transformer (9601 Export pH Meter)	16729
	Fig. 9;		
	5, Fig. 8	CIRCUIT BOARD ASSEMBLY	45824
R21	6, Fig. 9	Resistor, 2 meg	2209
R3, R23	5, Fig. 9	Resistor, 22 meg	8853
R13	1, Fig. 9	Resistor, .16 meg	15080
R27	2, Fig. 9	Resistor, 1000 ohms	8055
R17	3, Fig. 9	Resistor, 82,000 ohms	8098
R29	4, Fig. 9	Resistor, .12 meg	8099
R30	7, Fig. 9	Resistor, 8.2 meg	8860
R4	8, Fig. 9	Resistor, 10 meg	11180
R19	9, Fig. 9	Resistor, 10 meg	8154
R22	10, Fig. 9	Resistor, 8200 ohms	20567
R18	11, Fig. 9	Resistor, 5.1 meg	10624
R10	12, Fig. 9	Resistor, 27,000 ohms	15058
R9	13, Fig. 9	Resistor, 56,000 ohms	15068
R15	14, Fig. 9	Resistor, 82,000 ohms	15072
R16	15, Fig. 9	Resistor, .1 meg	15074
R11	16, Fig. 9	Resistor, 27 meg	15084
R25, R26	17, Fig. 9	Resistor, 47,000 ohms	16631
R12	47, Fig, 9	Resistor, 4.7 meg	12458
R5	18, Fig. 9	Resistor, 6200 ohms	99618
R40	51, Fig. 9	Resistor, 300 ohms	713
R28	5A, Fig. 9	Resistor	Selected
R20	22, Fig. 9	Resistor, 51,000 ohms	43133
R7, R8	23, Fig. 9	Resistor, 200 ohms	16638
R41	21, Fig. 9	Resistor, 160 ohms	896
F1	25, Fig. 9	Fuse, 1 amp	16640
C9, C16	26, Fig. 9	Capacitor, .1 mfd	16641
C15	27, Fig. 9	Capacitor, 4 mfd	16642

SYMBOL	REFERENCE	DESCRIPTION	BECKMAN PART
C11	28, Fig. 9	Capacitor, 20 mfd	16643
C3	50, Fig. 9	Capacitor, .005 mfd	10073
C4	30, Fig. 9	Capacitor, .001 mfd	15020
C5	31, Fig. 9	Capacitor, 1.0 mfd	20338
C6	29, Fig. 9	Capacitor, 200 mfd	16644
C10	32, Fig. 9	Capacitor, 20 mfd	16647
C12, C13	33, Fig. 9	Capacitor, 20 mfd	16648
C14	45, Fig. 9	Capacitor, .22 mfd	16692
C19	49, Fig. 9	Capacitor, .01 mfd	91712
C20		Capacitor, 390 mmfd	24671
C21	20, Fig. 9	Capacitor, .22 mfd	16629
	13, Fig. 8	Power Cord, 115V	16615
	13, Fig. 8	Cable Assembly	72768
	Fig. 10;		
	8, Fig. 8	RELAY CAN ASSEMBLY	45615
	7, Fig. 10	Tube, Electronic, 5886	43284
C2	3, Fig. 10	Capacitor, Polystyrene, 250 mmfd	43074
C1	1, Fig. 10	Capacitor, .01 mfd	29839
R38	4, Fig. 10	Resistor, 10 meg	8154
R39	8, Fig. 10	Resistor, 22 meg	8853
	5, Fig. 10	Compression Spring	16627
R2	9, Fig. 10	Resistor, .47 meg	8106
	2, Fig. 10	Relay	16664
	6, Fig. 10	Input Cable Assembly	28767
		CASE ASSEMBLY	16671
	1, Fig. 10A	Case	16672
	2, Fig. 10A	Switch Assembly	16674
	3, Fig. 10A	Meter	45845
	4, Fig. 10A	Bracket, Meter	28878
	5, Fig. 10A	Panel, Control	45068
	6, Fig. 10A	Plate, Temperature Dial	16686
	7, Fig. 10A	Button Assembly, Push	16687
	8, Fig. 10A	Knob, Pointer	16742
	9, Fig. 10A	Knob, Asymmetry	16743
	10, Fig. 10A	Screw, Round Head, 6-32 x 3/16	Std. Item
	11, Fig. 10A	Screw, Pan Head, 8-32 x 1/4	Std. Item
	12, Fig. 10A	Washer, Split, No. 6	Std. Item
	13, Fig. 10A	Washer, Split, No 8	Std. Item
R32	14, Fig. 10A	Potentiometer, 2000 ohms (Temperature Compensator Control)	16678
	15, Fig. 10A	Washer, Flat, No. 8	Std. Item
R35	16, Fig. 10A	Potentiometer, .5 meg (Asymmetry Control)	16679
	17, Fig. 10A	Cable Assembly	28768
	18, Fig. 10A	Lug	Std. Item
	19, Fig. 10A	Bracket, Switch	45076
	20, Fig. 10A	Screw, Flat Head, 8-32 x 1/4 Hex Socket	Std. Item
	21, Fig. 10A	Washer, Large, Flat, No. 8	Std. Item
	22, Fig. 10A	Washer, Flat, No. 6	Std. Item
	23, Fig. 10A	Insert, Threaded, 8-32	8383
R31, R33	24, Fig. 10A	Resistor, 3500 ohms	79236
R34	25, Fig. 10A	Resistor, .51 meg	9092


12. THIS DRAWING APPLIES TO INSTRUMENT SERIAL NO.'S
FOR (9600) 180674 THRU 180797
180799 THRU 181134
181842 THRU 182006
182027 AND SUBSEQUENT
FOR (9601) 170567 AND SUBSEQUENT
FOR (9602) 147005 AND SUBSEQUENT
FOR (9603) ALL INSTRUMENTS
INDICATES PIN CONNECTIONS ON CASE ASSEMBLY CONNECTOR.
INDICATES PIN CONNECTIONS OF INPUT CAN ASSEMBLY.
WHEN AMPLIFIER TUBES OF RELAY CAN ASSEMBLY ARE REPLACED, LOCK DOWN BOTH THE ⊕ 700 AND AUTO PUSH BUTTON, RELEASE BOTH STAND-BY AND READ PUSH BUTTON, ADJUST BALANCE CONTROL UNTIL METER NEEDLE STAYS ON SCALE.
THE AUTO SWITCH RELEASES THE MANUAL SWITCH, AND REMOVES THE MANUAL TEMPERATURE COMPENSATOR FROM THE CIRCUIT SO THAT AN AUTOMATIC THERMO-COMPENSATOR MAY BE USED.
9. R 42 INSTALLED ON INSTRUMENTS BEARING SERIAL NO. 219092 AND SUBSEQUENT FOR 9601 & 9603.
8. R 42 INSTALLED ON INSTRUMENTS BEARING SERIAL NO. 215512 AND SUBSEQUENT FOR 9600 & 9602.
7. D.C. VOLTAGES MEASURED WITH RESPECT TO CIRCUIT GROUND.
MAN, AUTO, MV ⊕ 700 AND MV 1400 PUSH BUTTON SWITCHES OPERATE A COMMON LATCH BAR AND ARE SHOWN IN THE MAN POSITION.
STAND-BY AND READ PUSH BUTTON SWITCHES OPERATE A COMMON LATCH BAR AND ARE SHOWN IN THE STAND-BY POSITION.
SHIELD CONNECTION MADE WITHIN TRANSFORMER
3. ALL CAPACITOR VALUES IN MICROFARADS UNLESS OTHERWISE SPECIFIED.
2. ALL RESISTOR VALUES IN OHMS UNLESS OTHERWISE SPECIFIED.
RELAY CONTACTS SHOWN IN NORMAL POSITION.
INPUT
INPUT CAN
RELAY
REF.
SOLUTION GROUND
STAND BY
READ
ELECTRODE
RECORDER
100-0-100 μA
THERMO COMPENSATOR
CIRCUIT GND
HEATERS
BOTTOM PLATE
EARTH CHASSIS
+80 V SUPPLY
-85 V SUPPLY
SIMPLIFIED SCHEMATIC OF DOMINANT LOAD ON POWER SUPPLY. (THESE COMPONENTS ALSO APPEAR WITHIN THE MAIN DIAGRAM).
110, 125, 145 200, 225, 250 VAC 40-60~
ALTERNATE CIRCUIT FOR 9601 & 9603
REVISED & REDRAWN

FIGURES 11 AND 12 CIRCUIT DIAGRAM (9600-9602 ZEROMATIC: 9601-9603 ZEROMATIC)

SECTION 8

8. INSTRUCTIONS FOR 9601-9603 (EXPORT) ZEROMATIC

8.1 GENERAL.

All instructions in the preceding sections of this Instruction Manual apply to the 9601-9603 (Export) ZEROMATIC, as well as to the 9600-9602 ZEROMATIC. A complete circuit diagram for the 9601-9603 is given in Figure 12.

8.2 POWER TRANSFORMER

8.2.1 Description.

The 9601-9603 ZEROMATIC is provided with a special Power Transformer which permits operation of the instrument on a-c voltages of 110, 125, 145, 200, 225, or 250 volts, on frequencies of 40 to 60 cycles. The Inset in Figure 8 illustrates the appearance and position of this Transformer and the Transformer Tap Switch by which the Transformer is adjusted for various line voltages.

8.2.2 Adjusting Power Transformer.

Before connecting the 9601 or 9603 ZEROMATIC to an electrical source, set the Tap Switch on the top of the Transformer at the position which most nearly corresponds to the actual line voltage. To adjust the Transformer for proper operation at the available voltage, follow the procedure outlined below:

(1) Turn the instrument on its back and remove the four corner screws from the Bottom Cover Plate. (See Figure 2.)

(2) Turn the instrument right side up, carefully lift plastic case off the instrument, and set case aside.

(3) Turn the Transformer Tap Switch to the value most nearly corresponding to the line voltage.

(4) Tighten the set-screw in the Tap Switch to lock the switch in the desired position.

(5) Replace plastic case and attach to Bottom Cover Plate by replacing screws removed in (1).

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